Texas Commission on Environmental Quality

INTEROFFICE MEMORANDUM

To: Luda Voskov, P.G.
Remediation Division

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From: Charles D. Stone, P.G., P.E.
Remediation Division, Technical Support Section

Subject: Technical Review: *Draft Chemical Fate and Transport Modeling Study – San Jacinto River Waste Pits Superfund Site*, February 2012.

Per request, a technical review of the subject report was performed for the purpose of evaluating the San Jacinto River Waste Pits (SJRWP) Superfund site chemical fate and transport modeling effort. This technical review communicates TCEQ concerns and recommendations regarding the modeling effort.

Sec A Technical Review Summary:

A.1 The purpose of the chemical fate and transport modeling described in the subject report is to simulate physical and chemical processes that are responsible for the distribution of site-specific COCs in the vicinity of the San Jacinto River Waste Pits Superfund Site ("Study Area"; Sec 1.3, Subject Report). The results of the chemical fate and transport model are expected to supplement the forthcoming RI/FS process.

A.2 The numerical modeling of the San Jacinto River sediment system required the coupling of different models to simulate numerous physical processes associated with the modeling objective.

A.3 The Study Area physical system model comprises three (3) major elements: hydrodynamics (Sec's B, C and D), sediment transport (Sec's E, F, H and I) and chemical fate and transport (Sec's J, K, L, M and N).

Sec B Hydrodynamic Model - General:

B.1 The simulation of hydrodynamic processes in the Study Area is based on the Environmental Fluid Dynamics Code (EFDC) package (e.g., USEPA, 2002; Hamrick, 1992). The model simulates temporal and spatial changes of water flow, bathymetry, geometry, water depth, current velocity for a range of flow regimes and conditions in the Study Area. Data generated by EFDC were used as input for the sediment transport model (see Item A.3).

B.2 EFDC calculates finite-difference solutions to numerous hydrodynamic equations for cells in the numerical grid that comprises the Study Area through time (USEPA, 2002). The entire model is represented by a two-dimensional numerical grid comprised of both curvilinear cells (narrow channelized areas) and rectangular cells (larger intertidal areas). The model domain contains 6,420 cells.

B.3 The resolution of the rectangular grid cells is approximately 0.23 acres in the vicinity

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of the northern impoundment and approximately 2.0 acres elsewhere in the larger intertidal area.

It is assumed for the physical model that the water column and flow conditions are non-stratified. Therefore, EFDC is executed in the two-dimensional mode with the model domain consisting of a numerical grid that is comprised of a single cell layer. As such, all water column concentrations and some physical quantities are depth-averaged in each cell.

B.4 The bathymetry and floodplain topography of the model domain were used to define the thickness (water depth) of each cell. Various datasets were used to assign cell values. Where data were not available for individual cells, values were assigned by interpolation of existing cell data (Sec 3 and Append A, Subject Report).

Details of the interpolation method(s) are not provided in the subject report.

Sec C <u>Hydrodynamic Model – Water Surface Elevation Calibration</u>:

C.1 Model boundary conditions are based on freshwater inflow at Lake Houston Dam, freshwater flow into Houston Ship Channel, and water surface elevations at the downgradient edge of the model domain.

C.2 Inflow rates at the Lake Houston Dam include tainter gate discharge. However, the tainter gate position is adjustable and the methodology used to account for its rating curve with respect to its *height variability* should be documented.

C.3 Water surface elevations were used to define the downstream model domain boundary conditions for diurnal tidal ranges and storm surges through time. Time series water surface elevation data were obtained from gauges in the hydrologic system. In this system, two NOAA gauges exist: one at Battleship Texas State Park and the other at Morgan’s Point.

The gauge station at Battleship Texas is located at the confluence of the Houston Ship Channel and the San Jacinto River (e.g., Fig 3-5, Subject Report), downstream of the subject site. The gauge station at Morgan’s Point is located 8 miles downstream from Battleship Texas at the mouth of the San Jacinto River on Galveston Bay (Fig 3-11, Subject Report).

C.4 Although the Battleship Texas gauge station is located at the downstream boundary of the subject model domain it was not used because verified water surface elevation data are available “intermittently” from 2002 (Sec 3.3.3, Subject Report). Therefore, the 21-year record of water surface elevation data from Morgan’s Point (8 miles downstream from the model domain boundary) was used for calibration purposes.

The use of data from the Morgan’s Point gauge station is justified in the subject report by comparing water surface elevations at both the Battleship Texas station and the Morgan’s Point station during a 4-month low-flow, tidally dominated period (Sec 3.4, Subject Report) from April 2007 to July 2007 (Fig 3-12, Subject Report).

C.5 Evaluation of the water surface elevation data from both gauge stations (Item C.4) indicates the data are well correlated over the four-month period. It is upon this conclusion that the use of the Morgan's Point data is justified as the basis for calibration of hydrodynamic simulations within the subject model domain.

However, the data also exhibit a variability of water surface elevation that is consistent with relatively normal tidal fluctuations which lacks any significant return or surge event.

C.6 The TCEQ believes that the hydraulic regime at the confluence of the Houston Ship Channel at the San Jacinto River (Battleship Texas gauge station) is fundamentally different than that which occurs at the mouth of the San Jacinto River at Galveston Bay (Morgan's Point gauge station). While approximately symmetrical tidal currents can be expected at both the Battleship Texas and Morgan's Point gauge stations during non-event periods, the symmetry no longer exists during periods of flooding. A decoupling of water surface elevations between stations is expected during flood events due to a local heightening of water surface elevation from increased freshwater flow at the mouth of a river compared to that of the more tidal-influenced in the open bay (e.g., Thomann, 1987).

Consequently, the TCEQ concludes that the water surface elevation response at the downgradient model domain boundary (Battleship Texas) would be significantly different than the water surface elevation response downstream at Galveston Bay (Morgan's Point) during a flood or surge event. As such, the use of data from Morgan's Point appears to be inappropriate for use in calibrating the subject model.

C.7 The TCEQ's concern regarding the calibration of the subject model by using water surface elevation data from Morgan's Point may be ameliorated by following standard calibration procedures recommended for the EFDC model. Hamrick (1992) advises that a calibrated model can be verified by "*... simulating or predicting an entirely different response.*"

C.8 *For the purpose of satisfying the necessary verification of the hydrodynamic model calibration, the TCEQ recommends the following procedure*: 1) use the current model calibrated with non-event water surface elevation data, 2) find a period of time for which data exist at the Battleship Texas station <u>and</u> over which a significant flood event is observed, 3) run the EFDC model, as calibrated, 4) from the resulting model run: compare the simulated water surface elevations at Battleship Texas (which is contained within the model domain against the actual data collected at the same gauge station, and finally 5) from the resulting model run: compare the model-predicted water surface elevations at Battleship Texas against the observed water surface elevations at the Morgan's Point gauge station.

By this exercise, it may be possible to determine whether event-driven decoupling of water surface elevations is observable and on what scale it may occur.

Sec D <u>Hydrodynamic Model – Current Velocity Calibration</u>:

D.1 The current velocity calibration method used time-series current velocities measured at locations within the model domain. Two (2) periods of time-series current velocity data were used: June 13 – July 7, 2010 and May 10 – July 13, 2011.

D.2 During the 2010 time period (Item D.1) inflow from the Lake Houston Dam ranged between 0 cfs to 21,000 cfs (Sec 3.4, Subject Report) that is characterized as representing "higher flow conditions" (Sec 3.4, Subject Report). However, the TCEQ notes that an inflow rate of 21,000 cfs represents a flow event with a return period that is significantly less than two (2) years (Fig 3-7, Subject Report). An inflow rate of 21,000 cfs represents relatively low-flow conditions.

D.3 During the 2011 time period (Item D.1) there was no inflow from the Lake Houston Dam. Therefore, data from the 2011 time period are representative of low-flow conditions that are *less than* the mean flow rate.

D.4 Current velocities were calibrated by comparing observed and predicted values against observed and predicted values of water depth (Sec 3.4, Subject Report). Correlation between current velocity and water depth values was optimized by adjusting the effective bed roughness parameter. The calibration correlation had the best agreement using an effective bed roughness value of 1.0 cm (Sec 3.4, Subject Report).

D.5 An effective bed roughness value of 1.0 cm was used for the current velocity calibration (Item D.4). However, in the sediment transport modeling, bed shear stress was calculated using an effective bed roughness value of 2 mm (Sec 1.1, Append G <u>and</u> Sec 4.2.2; Subject Report).

The apparent use of a model-run effective bed roughness value that is different from the calibration effective bed roughness value tends to violate the purpose of determining calibration values and introduces potentially significant uncertainty into the simulation results for that physical process.

Sec E <u>Sediment Transport Model – Sediment Properties</u>

E.1 Bed property data from the hydrodynamic model (Sec D) are used as input to the sediment transport model, SEDZLJ (e.g., James et al., 2005). For cohesive sediment, Sedflume measurements were obtained from experiments on fifteen (15) cohesive sediment cores from the subject model domain. The data are tabulated in Tables E-1 through E-5 (Append E, Subject Report).

E.2 A single value for the three (3) erosion rate parameters was obtained for each of the five (5) depth intervals from each core (Item E.1). A "log-average" (geometric mean) value was determined for the proportionality constant, A (Equation E-1, Subject Report), at each depth interval (Table E-6, Subject Report).

As is normal, the geometric mean results in values of A for the Sedflume data sets (Table E-1 through Table E-5, Subject Report) are significantly lower than the arithmetic mean for the same data sets. Use of the lower values of A results in significantly *lower values of the average gross erosion rates* for each depth interval (Equation E-2, Subject Report).

No rationale is provided to justify use of the geometric mean for the proportionality constant.

E.3 The results of the Sedflume experiments also were used to develop average critical shear stress (τ_{cr}) values for each sediment layer (e.g., Table E-1 through Table E-5, Subject Report). However, the *average* critical shear stress (τ_{cr}) values (Table E-6, Subject Report) were determined using the arithmetic mean, not the geometric mean (as for the proportionality constant, see Item E.2) which results in the significantly higher value of the two means.

The use of the higher arithmetic average value, rather than the lower geometric average value for the critical shear stress (τ_{cr}) results in a lower gross erosion rate (E_{gross}; e.g., Equation E-2).

Together with the geometric average of the proportionality constant (Item E.2), the use of the arithmetic average of critical shear stress *reinforces a biased tendency for lower erosion* in the model domain.

E.4 The erosion parameters (A, n) could not be adequately varied spatially about the model domain, so each model layer was assigned the same values (Sec 4.2.2, Subject Report) as listed in Table 4-2 (Subject Report).

E.5 The boundary condition for in-coming sediment load to the model domain is 100% Class 1 sediment. The mass of in-coming sediment load is considered to be 60% of that entering Lake Houston via associated tributaries (Table 4-3 and Table 4-4, Subject Report), assuming Lake Houston has a 40% trapping efficiency (based on "professional judgment," Sec 4.5, Subject Report).

E.6 The TCEQ notes that a consequence of designating the boundary condition for in-coming sediment load to be a proportion of sediment load entering Lake Houston (Item E.5), the in-coming sediment load must equal 0.0 mg/L during periods when there is no discharge at the Lake Houston Dam. This should be confirmed, along with the potential consequence to model calibration (see Item I.4).

Sec F <u>Sediment Transport Model – Bed Properties</u>:

F.1 Figure 4-2 (Subject Report) shows the sediment bed assignments on the numerical grid of the study area. All curvilinear grid cells used in the hydrodynamic model domain (Item B.2) are excluded from the sediment transport model domain and designated "hard bottom." "Hard bottom" cells are characterized by no sediment erosion and no sediment deposition (Sec 4.2.2, Subject Report).

F.2 Sediment bed grain-size variation is simulated using four (4) discrete particle-size classes (Sec 4.2.1, Subject Report). Class 1 is cohesive and Class 2 through Class 4 are non-cohesive (e.g., Table 4-1, Subject Report).

F.3 Based on field evaluation, 30% of the randomly selected sediment bed grab samples were classified as cohesive (Item F.2). However, after grain-size analyses 53% of the grab samples from the same locations were categorized as cohesive Class 1 (Appendix C, Subject Report). Based on these data, *80% of the sediment bed in the study area is classified as cohesive* (Sec 4.2.2 and Figure 4-2, Subject Report).

F.4 Class 1 cohesive bed sediment (Item F.3) was classified as having a median particle size (D_{50}) of *0.25 mm* (Sec 4.2.2 and Appendix C, Subject Report). Therefore, cohesive bed sediment is characterized by a grain-size population where 50% of the particle mass is medium sand or larger (e.g., Folk, 1972) and can be classified as "fine to medium sand."

In a description of SEDZLJ (Item E.1), the program module is used to simulate sediment bed erosion and deposition (Sec 4.1, Subject Report). Sediment grain sizes larger than 0.2 mm are considered to be non-cohesive (James et al., 2005).

Based on the discussion here, the TCEQ concludes that most of the sediment comprising the cohesive Class 1 category is composed of grains defined as non-cohesive. The simulation of sediment ascribed as cohesive whose dominant make-up is actually non-cohesive leads to results that adversely affect the goal of realistic sediment bed simulation. One specific result is the tendency for Class 1 sediment gross erosion to be under-estimated (e.g., Item E.3).

F.5 Confirmation that cohesive Class 1 sediment bed category is characterized by D_{50} < 0.25 mm (Item F.4) is provided in Figure 4-6 (Subject Report), which shows that the distribution of numerous cohesive Class 1 D_{50} is comprised of median grain size up to 0.25 mm.

F.6 The gross erosion rate for cohesive sediments is dependent on the proportional constant and the skin friction shear stress (Equation G-26, Subject Report). If the skin friction shear stress is less than the critical shear stress, no erosion occurs.

However, use of the arithmetic mean (instead of geometric mean) for the critical shear stress makes any erosion less likely (Item E.3). While use of the geometric mean (instead of arithmetic mean) for the proportionality constant decreases the amount of gross erosion that would occur (Item E.2).

F.7 *The TCEQ recommends including a map in the subject report that displays gross erosion rates in the model domain, including all cells for which $E_{gross}=0.0$, based on Equation G-26.*

F.8 The cohesive Class 1 sediment erosion flux to suspended load (vs bed load) is not based on class size D_{50}, rather, it is calibrated (e.g., Table 4.1, Subject Report).

The TCEQ notes the subject report does not provide information regarding the value(s) of effective diameter for Class 1 sediment resulting from the model calibration and recommends inclusion of such data.

F.9 The use of D_{50} < 0.25 mm grain size composition to characterize the cohesive Class 1 sediment category (Item F.4) results in biased model simulations that underestimate cohesive sediment erosion and resuspension (e.g., Equation G-25, etc.) and that overestimates cohesive sediment deposition rate (e.g., Equation G-35, etc.).

Sec G Sediment Transport Model – Settling Velocities:

G.1 The subject report indicates that the sediment transport model was, in part, calibrated using the settling speed of Class 1 sediment (Sec 4.3, Subject Report). The Class 1 settling speed used in the calibration is reported to be 1.3 m/d. However, the equation used for Class 1 (cohesive) settling cannot be discerned by the TCEQ from the information provided in the main text and Appendix G of subject report, or from James et al. (2005).

The TCEQ notes the omission from the subject report of information regarding the specific model used in the determination of the Class 1 settling speed and/or the equivalent effective median grain size of the Class 1 fraction.

Sec H <u>Sediment Transport Model – Radioisotope Core Study</u>:

H.1 An evaluation of net sedimentation rates in the model domain was performed using ^{137}Cs isotopy in sediment core samples. The ^{137}Cs systematics are considered favorable for use in fluvial environments characterized by intermittent deposition (e.g., Jeter, 2000; Van Metre et al., 1997, etc.).

H.2 Of the ten (10) cores used in the ^{137}Cs isotopic study, data from only one (1) core (SJR1oo5) were usable (e.g., Table F-3, Subject Report). Evaluation of the data from Core SJR1005 indicates there were only two (2) detections (Figure F-6).

The two (2) data points from Core SJR1005 were used to assign a date to the corresponding sediment depth (Appendix F, Subject Report) from which a net sedimentation range was determined (e.g., Table F-3, Subject Report). However, the subject report does not provide which of the four (4) typical interpolation methods (e.g., USGS, 2004) were used.

H.3 Use of ^{137}Cs isotopic data from a sediment core for determining net sedimentation rates and/or age dating is predicated upon corroborating data obtained from other cores in the same depositional system (e.g., USGS, 2004). However, in this instance, there are no such corroborating data.

Therefore, *the TCEQ is unable ascribe to the single ^{137}Cs net sedimentation rate (Item H.2) reliability or applicability to the model domain.*

H.4 An evaluation of the net sedimentation rates in the model domain was also performed using the ^{210}Pb isotopic system. Contrary to the more suitable applicability of the ^{137}Cs isotopic system to a depositional environment that is relatively dynamic (Item H.1), the ^{210}Pb system "*... performs best in relatively quiet depositional areas ...*" (Jeter, 2000). The ^{210}Pb system age dating method is "*... more useful for age-dating cores from low-sedimentation-rate lakes with undisturbed watersheds where the input of contaminants is dominated by atmospheric fallout ...*" and is less useful "*... in high-sedimentation-rate lakes with developed watersheds where the input of contaminants is dominated by fluvial loading from one or more streams ...*" (USGS, 2004).

As such, the ^{210}Pb method should be expected to be even more adversely affected by the depositional environment than that for the ^{137}Cs system and significantly less suitable to the relatively high-energy depositional environment that comprises the subject study area.

H.5 The ^{210}Pb study was performed on sediment core samples obtained from the same cores and same depths as that for the ^{137}Cs study (Appendix F, Subject Report).

H.6 The determination of net sedimentation rates by ^{210}Pb systematics is based on age dating of unsupported ^{210}Pb entering the system by atmospheric deposition (e.g., USGS, 2004). Unsupported Pb is assumed to enter the system (and be deposited) at a constant rate. Unsupported Pb must be distinguished from supported Pb that is in secular equilibrium ("geologic background" – e.g., Faure, 1977).

H.7 The ^{210}Pb data provided in Figures F-2 through Figure F-11 (Subject Report) display ^{210}Pb activity vs sediment depth. Figures F-12 through F-26 show ^{210}Pb activity with depth and supported ^{210}Pb values. However, the value of the supported ^{210}Pb varies from one core to another (compare Figure F-24 against Figure F-25). Since the supported ^{210}Pb values represent secular equilibrium (Item H.6), the supported ^{210}Pb activity level throughout a given depositional system must have the same value.

The significant variation of supported ^{210}Pb activity levels reported in Appendix F (Subject Report) indicates that: 1) the actual value of supported ^{210}Pb has not been adequately determined, and 2) sediment mixing occurs in a depositional system (model domain) that is too dynamic for the ^{210}Pb system to be useful (Item H.4).

H.8 The ^{137}Cs and ^{210}Pb activity analytical results were reported with significant experimental error (e.g., Figure F-2 through Figure F-11, Subject Report). Linear regression was performed to find the slope of the line defined by those ^{210}Pb data that were judged to be unsupported (Append F, Subject Report) versus their core depth to determine net sedimentation rates (Figure F-12 through Figure F-26, Subject Report).

However, the regressions do not incorporate the variance of experimental error associated with each datum. Therefore, a range of slopes and, consequently, net sedimentation rates, exists at each core location. Only mean net sedimentation rates are reported, but not the significant deviation inherent in the analyses.

The TCEQ notes significant range of net sedimentation rates highlighted by the regression method used, but which has not been quantified.

Sec I <u>Sediment Transport Model - Net Sedimentation Rates</u>:

I.1 Calibration of net sedimentation rates in the model domain are based on isotopic data from sediment cores (Sec H) and assumption of deposition of 100% Class 1 cohesive sediment (Sec 4.3, Subject Report). Table 4-5 summarizes the model calibration rates.

I.2 The location of the cores (Item I.1) used in calibration is shown in Figure 4.17 (Subject Report). Core SJR1006 is assigned the highest range of net sedimentation rates of all cores (Table 4-5, Subject Report). However, core SJR1006 is located in the same area as the original 2011 ADCP deployment (Figure B-1, Subject Report). The original deployment location was abandoned when the unit's mounting frame was found to be "*... partially buried with sediment due to commercial marine traffic ...*" (Appendix B, Subject Report) and moved to a second location further from marine traffic.

The TCEQ notes the general disparity between the isotopic net sedimentation rates and the predicted rates for the model domain (Figure 4-19). The TCEQ also notes that the net sedimentation rates at other core locations within the model domain are also affected by marine traffic and thereby adversely impact calibration.

I.3 The TCEQ notes the omission from the subject report of figures showing net erosion and net deposition within the model domain for specific return event simulations (e.g., 5-year, 10-year, 20-year, etc.).

I.4 The sediment transport model reliability is based, in part, on a sensitivity analysis using in-coming sediment load values at Lake Houston Dam (Sec 4.5, Subject Report) whose value is based on “professional judgment” (Item E.6).

The TCEQ notes that the assumed value of the in-coming sediment load is not adequately substantiated to be used as a reference value in a sensitivity analysis. Similarly, the contention that the model “… tends to under-predict net sedimentation rates …” *inside the Site Perimeter is based on the same unsubstantiated assumption.*

I.5 The TCEQ concurs that the “*… uncertainty in the model reliability is relatively high* …” (Sec 4.5, Subject Report) at small spatial scales. However, the TCEQ is unclear upon what data it is concluded that the model uncertainty decreases with increasing spatial scale (Sec 4.5, Subject Report).

Sec J <u>Chemical Fate and Transport Model - General</u>:

J.1 The fate and transport model analysis at the subject site is based on dioxins and furans (Sec5.2.1, Subject Report). Three (3) congeners: 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD), 2,3,7,8-tetrachlorodibenzofuran (TCDF) and octochlorodibenzo-*p*-dioxin (OCDD) were modeled. TCDD is used as a reference compound against which relative potency of other related compounds is compared (e.g., USEPA, 2008).

J.2 The fate and transport model comprises a grid that is the same as that used in the hydrodynamic model (Item B.2 through B.4) and the sediment transport model. However, the “active” domain of the sediment transport model is significantly smaller than that of the hydrodynamic model since upstream and downstream portions of the model grid in the sediment transport model are designated as “hard bottom” where bed erosion and deposition calculations are turned off (e.g., Item F.1; Figure 4-3, Subject Report). Additionally, no fate and transport calculations were performed upstream of the sediment transport model “active domain” (Sec 5.2.2, Subject Report).

Therefore, fate and transport simulations occurred in the *downstream* portions of the same study area grid where sediment transport model calculations were “inactive.”

J.3 The sediment bed in the fate model is discretized into sixteen (16) 3-inch thick layers (total = 48 in) with the uppermost six (6) inches designated as the “surficial sediment zone” (Sec 5.2.2, Subject Report).

Sec K <u>Chemical Fate and Transport Model – Boundary and Initial Conditions</u>:

K.1 Due to insufficient data, the normal process for determining the fate and transport boundary conditions for contaminant concentrations could not be performed (Sec 5.2.3, Subject Report). Instead, upstream loading concentrations were determined using average water column data from two (2) upstream TMDL stations and two (2) downstream TMDL stations, all of which are outside the sediment transport model's "active" grid (Item J.2).

The TCEQ notes the omission from the subject report of the TMDL data sets and corresponding data quality used to determine contaminant concentration boundary conditions presented in Table 5-1 (Subject Report).

K.2 Initial model conditions for sediment concentrations of TCDD, TCDF and OCDD were adapted to the model domain from data collected for TMDL studies between 2002 and 2005 (Sec 5.2.5.2). The initial grid values appear in Figure 5-7a through Figure 5-7c (Subject Report).

The upstream initial model sediment concentration was determined by averaging five (5) values measured in the San Jacinto River (Sec 5.2.5.2, Subject Report). However, the TCEQ notes that the time period and flow conditions of the sampling event(s) used are omitted in subject report.

K.3 Congener concentration data for deep sediment (> 6 inches) in the 2005 data set are sparse (Sec 5.2.5.2, Subject Report). Consequently, deep sediment initial concentrations were set equal to surface sediment concentrations. A summary narrative describes the results of a sensitivity analysis in which simulations using deep sediments with initial concentrations "two orders of magnitude" higher than surface sediment produced results "nearly identical" to those using initial concentrations equal to surface sediment concentrations (Sec 5.2.5.2, Subject Report).

The TCEQ notes that the sensitivity analysis was performed using problematic net sedimentation rates (Item H.7) and Class 1 sediment characteristics (Item F.5 and Item F.6) and the conclusion is fraught significant and unquantitated uncertainty.

Sec L <u>Chemical Fate and Transport Model – Partitioning</u>:

L.1 The determination of site-specific contaminant partitioning in the water column is described using various data sets, numerous literature sources and methods of regression analysis (Sec 5.2.6, Subject Report). While the validity of the approaches used in the determinations of contaminant partitioning are not in dispute here, the procedure highlights the high range of variance inherent in the data sets and, in turn, the apparent low degree of correlation associated with the resulting regressions (e.g., Figure 5-9, Subject Report). The subject report provides no discussion of the magnitude of statistical uncertainty associated with the selected partitioning values.

L.2 While the range of site-specific partitioning coefficients inherent in the approaches used in their determination is not described (Item L.1), a sensitivity analysis was performed (Sec 5.3.3.2.3, Subject Report). In the sensitivity analyses, the partition coefficients were varied within a range of ±0.3 log units resulting in relatively insignificant effect on the modeling results.

The TCEQ notes that the sensitivity analyses were performed over a range of partitioning coefficients that significantly under-estimates the range of variance demonstrated in their determination. The TCEQ acknowledges that defining the statistical variance associated with the coefficients' determination, then performing sensitivity analyses using a more appropriate coefficient range may provide a more meaningful gauge for the sensitivity analyses.

L.3 The particle-phase contaminant concentration (Sec 5.2.6.2, Subject Report) is determined using the particulate dry mass density in sediment bed (Equation 4, Appendix H, Subject Report). The dry density of Class 1 sediment is 0.83 g/cm^3 (Sec 4.2.2, Subject Report), a fine-to-medium sand (Item F.4) consisting mostly of silicate mineral grains with a sediment dry bulk density of 1.4 g/cm^3 (Appendix C <u>and</u> Sec 5.2.8.1, Subject Report). Hence, particle-phase contaminant concentrations for total suspended solids in the water column are determined using the dry density of a sediment class (Class 1) for which much of the particles are too coarse and dense to be "suspended."

Therefore the mass of contaminant for total suspended solids (in water column) is over-estimated, and the contaminant mass in sediment is under-estimated.

L.4 Dissolved organic carbon concentrations in the water column vary through time (Figure 5-13, Subject Report). A constant value for dissolved organic carbon concentration is set in the model at an *average* value of 10 mg/L (Sec 5.2.7.3, Subject Report).

However, the TCEQ notes that visual inspection of the plotted TCEQ TMDL data upon which the average value is attributed indicates the average dissolved organic carbon value is significantly less than 10 mg/L.

L.5 Class 1 sediment is defined in Sec 5.2.8.2.1 (Subject Report) as being composed of particle size < 62 µm. Class 1 sediment is defined as "cohesive" (Item F.4). However, "cohesive" sediment is defined as D_{50}=250 µm (Item F.4, Item F.5; Sec 4.2.2 <u>and</u> Append C, Subject Report). The preceding statements highlight an apparent incongruity regarding the definition(s) of Class 1 sediment, "cohesive" sediment, and grain size(s) of Class 1 sediment and "cohesive" sediment.

The TCEQ notes the need for clarification of the interrelationship of the aforementioned terms and definitions.

L.6 Pore water dissolved organic concentrations measured at locations outside the model domain (Patrick Bayou and Lavaca Bay) were used to establish a possible range of model values (Sec 5.2.8.2.2, Subject Report). A value of 10 mg/L, less than the combined range of measured values, was selected for the model input (5.2.8.2.2, Subject Report).

L.7 A mixing rate between the upper two (2) sediment layers (6 inches) is assumed to be 10^{-7} cm^2/sec, based on a range from literature (Sec 5.2.8.3.3, Subject Report).

Sec M <u>Chemical Fate and Transport Model – Calibration</u>:

M.1 Calibration of the fate and transport model is based on water column and surface sediment concentrations of TCDD, TCDF and OCDD throughout the model domain for pre-TCRA conditions (Sec 5.3.1, Subject Report).

M.2 Contaminant concentration calibration data for the water column and surface sediment were obtained during low-flow conditions (Sec 5.3.2.1.1, Subject Report). As such, it is not possible to evaluate the "goodness" of the calibration for other conditions (e.g., high-flow conditions).

M.3 The subject report acknowledges that the calibration of the subject fate and transport model has certain limitations, owing mainly to lack of temporal and spatial data (Sec 5.3.1, Subject Report). Consequently, values of certain critical model parameters (e.g., water column concentration boundary conditions, surface porewater concentrations) required adjustment in order to "… improve the 'fit' of the model predictions …" (Sec 5.3.1, Subject Report).

M.4 The results of spatially averaged model predictions for water column concentrations of dissolved and particulate-bound phases plotted against distance from Lake Houston Dam are shown on log-normal graphs (Figure 20a through 20c, Subject Report). As seen, the range of model data increases significantly around Mile 6 (Figure 5-17, Subject Report) and is attributable to averaging of lateral cells with variable concentrations which are projected onto a one-dimensional plot (Sec 5.3.2.1.1, Subject Report). However, although the range of the average concentration along the down-stream line is shown, the method of data visualization makes it impossible to assess the "fit" between predicted and measured values at specific locations where both exist.

M.5 The results of spatially averaged model predictions (Item M.4) for the region of the model domain upstream of Mile 6 (Figure 5-17, Subject Report) is a relatively narrow channel along which only one sample location exists (Sec 5.3.2.1.1, Subject Report). Therefore, the "predicted values" line and the lateral "average values" line are identical since there are no lateral cells to average, (Item M.4). The coincidence of the two lines in no way represents a "fit" of model predictions (Item M.3).

M.6 Fate and transport model predictions for the region of the model domain upstream of Mile 6 are based on the input from the sediment transport model in which no erosion or deposition is allowed to occur in the model (Item F.1). The degree to which the defined upstream sediment loading boundary condition (Item K.1) is affected by this model-defined condition may provide insight into the predictive capacity of the model in this portion of the domain.

M.7 Assessment of temporal trends of contaminants in surface sediment between 2005 and 2010 was performed on area-weighted concentrations from two (2) datasets through time (Sec 5.3.2.2, Subject Report). The assessment concludes that decreases of congener concentrations occurred during that period (Sec 5.3.2.2, Subject Report).

However, subject report would benefit from the inclusion of maps showing the sampling locations and Thiessen polygons for *each* event that was used in the assessment. Additionally, no information is provided with which to place the assessment into a context related to the historical flow regime prevalent prior to each sampling event.

M.8 The TCEQ notes the absence of discussion regarding the potential skewness of the datasets used in Figure 5.21a through Figure 5.21c (Subject Report). Using the methodology described in Item M.7, similar conclusions could be reached if more Thiessen polygons had lower average concentrations in 2010 *due to location* – and not actual decrease in sediment concentration. The distinction between skewed sample population and actual concentration decrease cannot be made from the information in subject report (see recommendation in Item M.7).

Sec N <u>Fate and Transport Model – Sensitivity Analysis</u>:

N.1 Sensitivity analyses were performed on TCDF and OCDD by varying some model conditions over a range of values in order to determine the relative magnitude of the effects to the final model results.

N.2 A sensitivity analysis was performed on the in-coming upstream sediment load concentration boundary condition (see Item E.6) at Mile 6. The concentration values were varied over a range of two (2) standard errors (95%) for TCDF and OCDD (Sec 5.3.3.2.1, Subject Report). However, the mean about which the standard errors range is derived from previous TMDL studies (Item K.2). As noted, the flow conditions represented by the mean in-coming sediment load concentration are not provided (Item K.2).

The TCEQ notes that the variance of sediment concentration (2σ) that is used in the sensitivity analyses cannot be correlated to *flow conditions*. This sensitivity analysis can be made more meaningful by correlating the variance of respective sediment concentrations to the corresponding range of flow conditions (return events), thereby providing more insight to the sensitivity analyses.

Sec O <u>References</u>:

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